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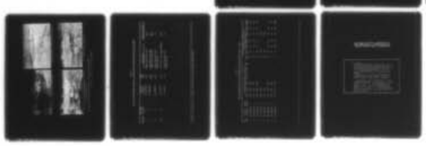

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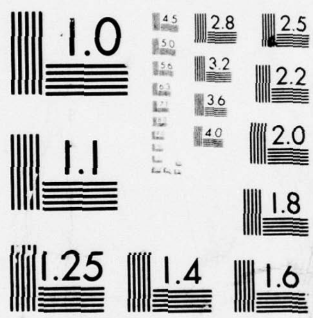

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SOIL/TERRAIN EVALUATION OF REPRESENTATIVE TEST AREAS HUNTER-LIGGETT MILITARY RESERVATION, CALIFORNIA

by

Adam A. Rula

Mobility and Environmental Systems Laboratory

Behzad Rohani

Soils and Pavements Laboratory

U. S. Army Engineer Waterways Experiment Station

P. O. Box 631, Vicksburg, Miss. 39180

June 1977

Final Report

Prepared for U. S. Army Materiel Development and Readiness Command, Project Manager for Selected Ammunitions, Picatinny Arsenal Dover, New Jersey 07801

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Remote Anti-Armor Mine System	Terrain
Soil penetration	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Hunter-Liggett Military Reservation was visited to conduct a soil/terrain evaluation of selected areas and to compare the soil strength data collected at the time of visit with the other 155mm XM718/741 Remote Anti-Armor Mine System (RAAMS) test areas previously characterized.

Soil/terrain data were collected at eight sites located in the valley used in TEMAWS experiments. The sites sampled included a range of soil types in

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20. Abstract (Continued).

undulating to rolling terrain. Most sites were covered with short grasses and broad-leaf plants.

All sites sampled were very firm at time of testing. The surface cone index ranged from 137 to 563+, and at 2 in. the cone index exceeded the capacity of the instrument (750+). The number of blows necessary to drive the dynamic cone penetrometer 0 to 3 in. ranged from 7 to 30, and for the surface foot ranged from 67 to 120.

For the range of soil strength measured, the mines will not penetrate the target and will bounce after impacting the ground. It is estimated from previous penetration analysis for RAAMS that the magnitude of the rigid body g forces that the RAAM can experience upon impacting such firm soils at 200 ft/sec would range from 5000 to 9000 g's.

Preface

This study was conducted on 6 December 1976 by personnel of the U. S. Army Engineer Waterways Experiment Station (WES) for the U. S. Army Materiel Development and Readiness Command (DARCOM) Project Manager for Selected Ammunitions, Picatinny Arsenal, Dover, New Jersey. Authority for the study is contained in a teletype from the Project Manager's office dated 29 November 1976 as part of DT II Testing of 155mm XM718/741 Remote Anti-Armor Mine System (RAAMS).

The study was conducted under the general supervision of Messrs. W. G. Shockley, Chief, Mobility and Environmental Systems Laboratory (MESL), and J. P. Sale, Chief, Soils and Pavements Laboratory (SPL). Field support activities at Hunter-Liggett Military Reservation were accomplished under the direction of COL Sykes, Tactical Effectiveness of Mine and Anti-Armor Weapons System (TEMAWS) Test Director. The report was prepared by Mr. A. A. Rula, Chief, Mobility Systems Division, MESL, and Dr. B. Rohani, Research Group, Soil Dynamics Division, SPL.

COL J. L. Cannon, CE, was Director of WES during the conduct of the study and the preparation of the report. Mr. F. R. Brown was Technical Director.

Contents

Conversion Factors, U. S. Customary to Metric (SI) Units of Measurement

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	0.0254	metres
feet	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
feet per second	0.3048	metres per second

SOIL/TERRAIN EVALUATION OF REPRESENTATIVE TEST AREAS

HUNTER-LIGGETT MILITARY RESERVATION, CALIFORNIA

Purpose of Evaluation and Background Information

1. At the request of U. S. Army Materiel Development and Readiness Command (DARCOM) Project Manager for Selected Ammunitions, Picatinny Arsenal, Dover, New Jersey, the undersigned representatives of the Waterways Experiment Station (WES) visited Hunter-Liggett Military Reservation (HLMR) on 6 December 1976. The purpose of the visit was to conduct a soil/terrain evaluation of a representative test area at HLMR, and to compare the soil strength data collected at the time of visit with the other Remote Anti-Armor Mine System (RAAMS) test areas already characterized. Authority for the visit is contained in TWX from the Project Manager's office dated 29 November 1976.

2. Upon arrival at HLMR, we met with COL Sykes, Tactical Effectiveness of Mine and Anti-Armor Weapons System (TEMAWS) test director and our point of contact, to select a representative area for sampling and to coordinate access to the area, since sampling was on a basis of non-interference with ongoing experimental testing. The valley running NW-SE in the vicinity of military grid coordinates FQ5977 was selected as representative since it contained most of the lowland soil types and terrain features.

3. We were informed that HLMR has experienced drought conditions for the past two years; that the ground is very hard and, where silty soil predominates, vehicle traffic produces very heavy dust conditions that impair visibility during test runs. During ongoing experiments, armored vehicles travel 20 mph through mined areas and 35 mph in unmined areas. Both areas are virtually bare. On the other hand, normal rainfall amounts in the wet season (Feb-Apr) moisten the bottomland silty and lean clay soils sufficiently to cause armored vehicles to immobilize for a period of about 45 days.

Soil/Terrain Description

4. Location of the TEMAWS experimental area is shown in Figure 1. General location of the sampled area is shown in Figure 2, and the specific locations of sampled sites are identified in Figure 3. Photographs of the area are given in Figure 4.

5. The soil/terrain data collected (Tables 1 and 2) are restricted to portions of the valley floor which are currently being used in TEMAWS experiments.

6. Sites 5a, 6, and 8, SE of the observation point (see Figure 3), are level, smooth, and covered sparsely with a short broadleaf plant and short grass, and the soil is predominantly a fat clay (CH) derived from calcareous parent materials. Although the soil can support combat vehicles in the wet season, the surface is slippery. Sites 1, 2, and 7, located near the NW-SE ridge on which the observation point is located, slope 1 to 2 percent, are about 60 percent covered with short broadleaf plants, are gently undulating, and have soils that are predominantly sandy clay (CL) and sandy silty clay (CL). These soils are probably derived from alluvial deposits of weathered granite. Near each site there is evidence that combat vehicles have become immobilized in these soils. Sites 3 and 4 occupy the lowest topographical position in the bottomland. They are nearly level and smooth, almost bare; and the soils, derived from alluvial deposits, are sandy silty clay (CL) and sandy silt (ML). There is much evidence near these sites of previous combat vehicle immobilizations. Site 5 is typical of the lower slopes adjacent to the hills. These slopes are undulating to rolling, and are covered with short grass, some short broadleaf plants, and widely spaced large (2-ft* diameter-at-breast height) oak trees. The soils, derived from weathered granite, are sandy clays and sandy silts. There is considerable evidence of past combat vehicle immobilizations.

7. In the valley SE of the observation point, small hills less than 50 ft in local relief protrude out of the valley floor interrupting the commonly level valley bottom. The slopes that occur on the small hills range up to about 5 percent. The soils and vegetation are similar to site 5. Also, gopher holes are quite common in the lesser plastic soils. The frequency of gopher holes in some areas has some influence on the strength data.

8. The soil strength data (Table 2) show that all sites tested were very firm. The surface cone index ranged from 137 to 563+. At the 2-in. depth, the cone index was 750+ (capacity of instrument). The dynamic cone penetration shows that soil strength increased with depth up to the 9-in. depth, after which soil strength decreased slightly in most cases. At sites 4 and 5, the 3- to 6-in. layer could not be penetrated with 50 blows. The number of blows necessary to drive the dynamic cone penetrometer 0 to 3 in. ranged from 7 to 30, and for the surface foot ranged from 67 to 120. For these values of dynamic cone penetration, the soil is considered very hard insofar as penetration of RAAM is concerned. For this range of soil strength, the mines will not penetrate the target and will bounce after impacting the ground. It is estimated, based on previous penetration analysis for RAAM, that the magnitude of the rigid body g forces that the RAAM can experience upon impacting such firm soils at 200 ft/sec would range from 5000 to 9000 g's.

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* A table of factors for converting U. S. customary units of measurement to metric units can be found on page 3.

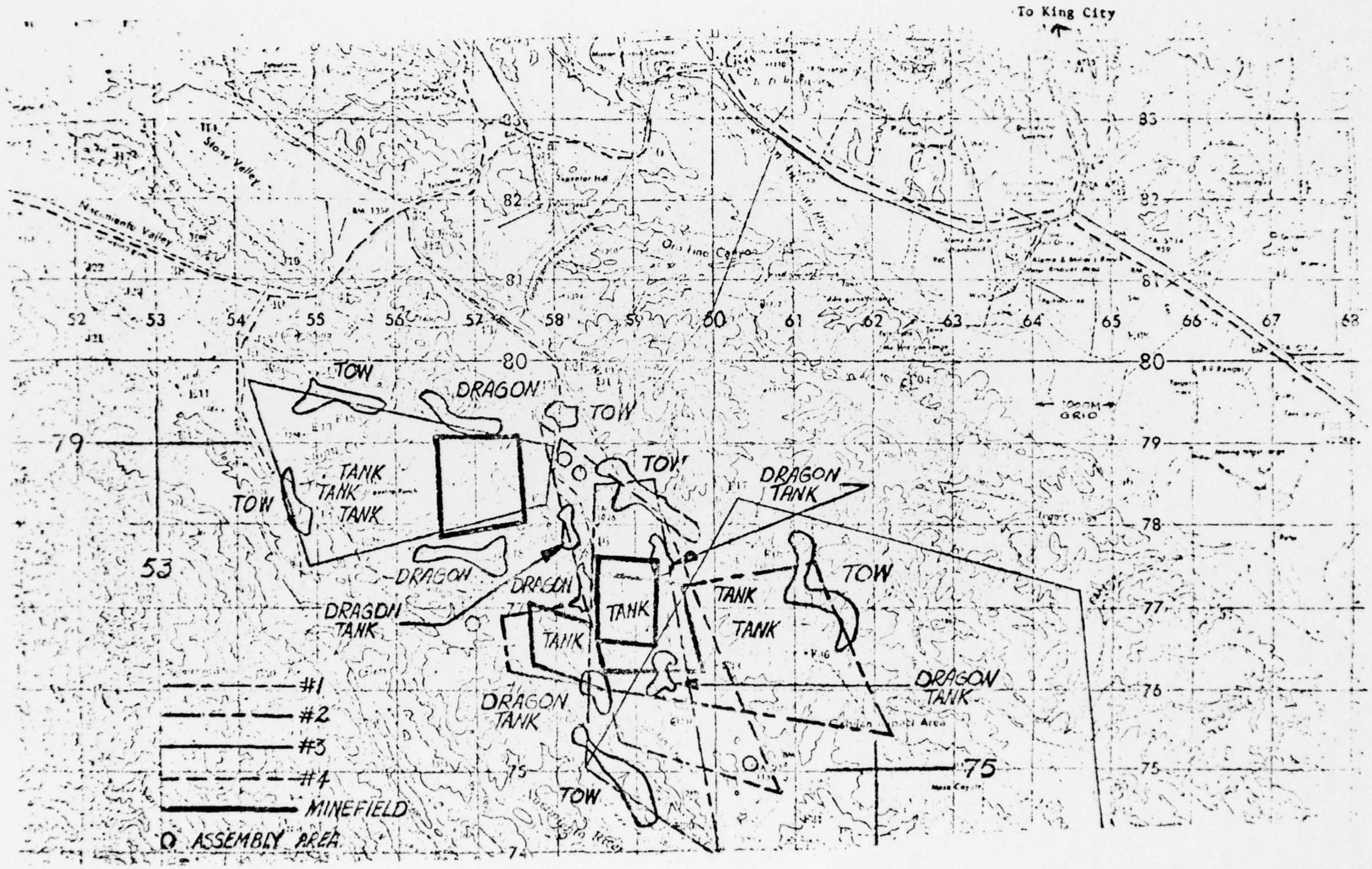


Figure 1. General layout of TEWMAWS experimental area

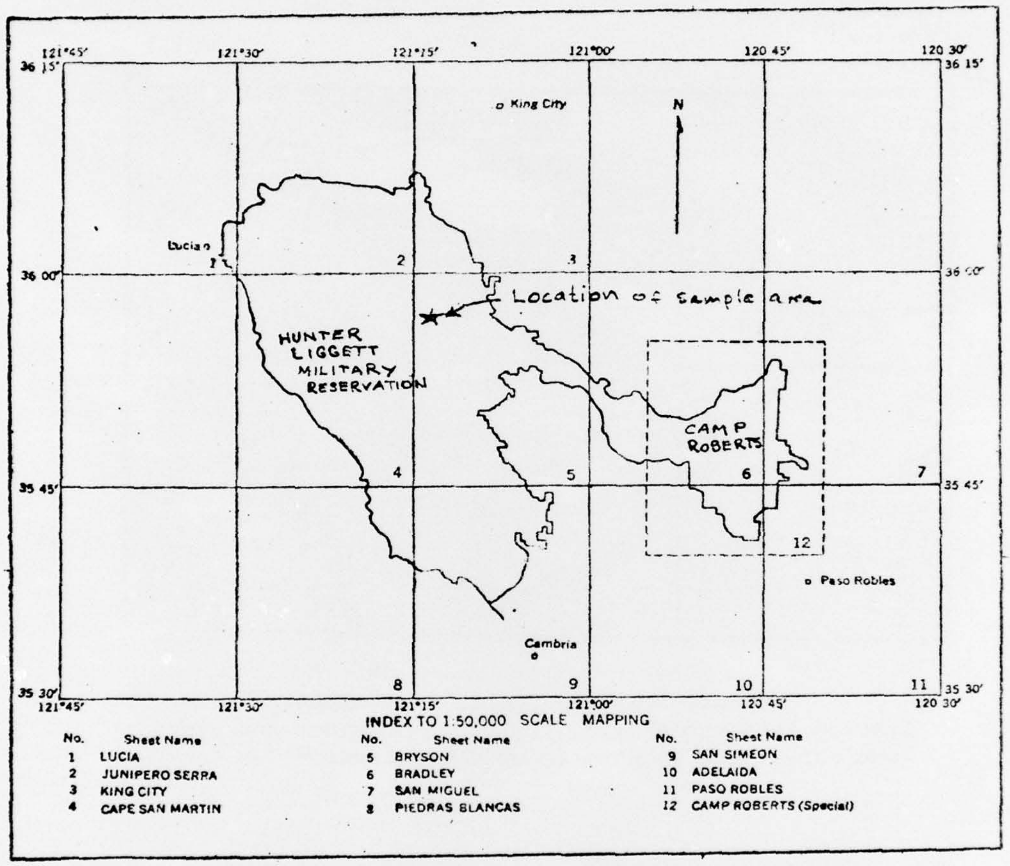
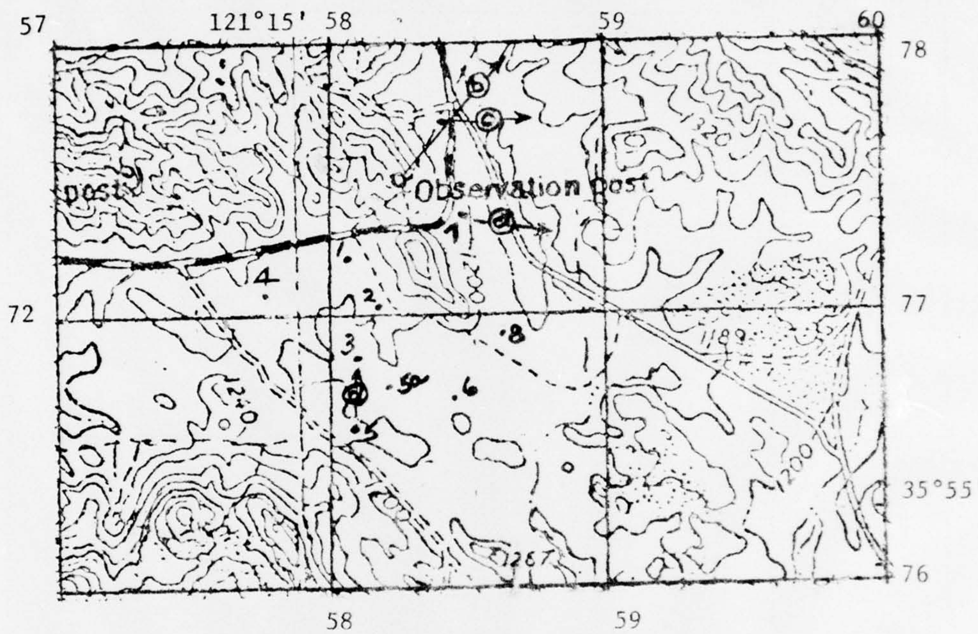


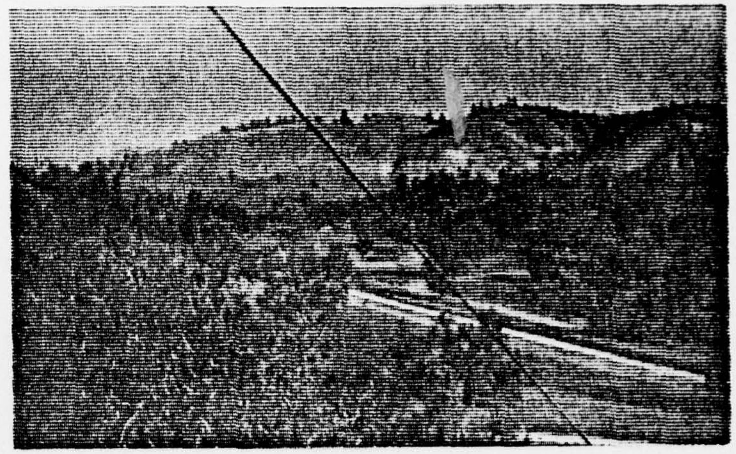
Figure 2. General location of sample area



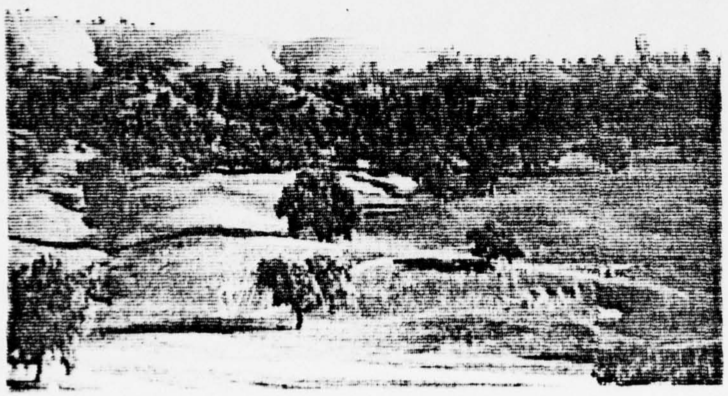
Numbers identify sample site numbers.
Circled letters identify photograph number, and arrow indicates line of site in which photograph was taken.

Figure 3. Specific location of sample sites

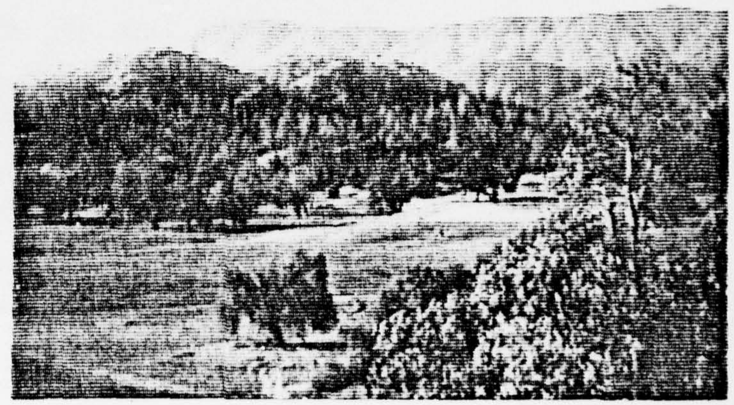
a. At site 7 looking east southeast*



b. Looking northeast from observation post



c. Looking east near road intersection northeast of observation post



d. Looking north from site 5

* See Figure 3 for location and line of sight of photographs

Figure 4. Photographs of areas sampled

Table 1

Soil Data for Selected Areas: Hunter-Liggett Military Reservation, Calif.

Site No.	Test Date Dec 76	Military Grid	Depth In.	Soil Type*	Moisture Content, %
1	6	FQ 58077720	0-12	Sandy Silty Clay (CL)	16.8
3	6	FQ 58087684	0-6	Sandy Silty Clay (CL)	14.1
			6-12	Sandy Silty Clay (CL)	14.6
5	6	FQ 58087657	0-12	Sandy Clay (CL) with Organic Matter	5.7
5a	6	FQ 58227674	0-12	Clay (CH) with Organic Matter	16.8
7	6	FQ 58467737	0-12	Sandy Clay (CL) with Organic Matter	8.7

* Visual. Classification in terms of Unified Soil Classification System (USCS).

Table 2

Soil Strength Data: Hunter-Liggett Military Reservation, Calif.

Site No.	Military Grid	Date Dec 76	Average Cone Index at Depth, In. 0	1	2	3	6	9	12	Average Dynamic Cone Penetration Blows per Layer, In. 0-3	3-6	6-9	9-12	0-6	6-12	0-12
1	FQ 58077720	6	467	740+	750+					11	18	21	20	27	41	68
2	FQ 58177702	6	293	747+	750+					23	23	28	26	46	54	100
3	FQ 58087684	6	333	708+	750+					14	20	17	16	34	33	67
4	FQ 57757706	6	563+	750+						30	50+			80+		
5	FQ 58087657	6	227	750+						16	50+			66+		
6	FQ 58457668	6	223	560+	708					10	20	28	18	30	46	76
7	FQ 58467737	6	203	530	750+					7	18	27	19	25	46	71
8	FQ 58627693	6	133	500	750+					25	35	40+	20	60	60+	120+

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Rula, Adam A

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